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MULTI-ITEM MULTI-OBJECTIVE INVENTORY MODEL WITH POSSIBLE CONSTRAINTS UNDER FUZZY ENVIRONMENT

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ABSTRACT

In this paper a multi item multi objective inventory model with three constraints; warehouse space, investment amount and the percentage of utilization of volume of the ware house space are taken to formulate the problem where the unit cost parameter which is depend upon the demand is imposed in fuzzy environment. Warehouse maintenance is one of the crucial parts of service operation. The warehouse space in the selling stores plays an important role in stoking the goods. In the proposed model, the warehouse space in the selling store is considered in volume. The model is illustrated with numerical example.

KEYWORDS: Multi-Objective Inventory Model, Triangular Fuzzy Number, Membership Function, Volume of the Warehouse

I. INTRODUCTION

The exact meaning of inventory is the stock of goods for future use (production/sales). The control of inventories of physical goods is a trouble common to all enterprises in any sector of an economy. In any industry, the inventories are important but they mean lockup of capital. The excess inventories are unwanted, which calls for controlling the inventories in the most beneficial way. The different types of costs (Purchasing cost, Setup cost, Holding cost, etc.) involved in inventory problems are affect the efficiency of an of an inventory control problem.

Warehouse space available in the selling store plays an essential role in inventory model. Warehouse space can be measured in terms of area and / or volume, but most of the researchers think about only the area of the warehouse space. Here the warehouse space in the selling store is measured in volume.

Silver [4] considered the classical inventory problem which was designed by considering that the demand rate of an item is constant and deterministic and the unit price of an item is measured to be constant and independent in nature. But in realistic situation, unit price and demand rate of an item may be related to each other. When the demand of an item is high, an item is produced in big numbers and fixed costs of production are spread over a big number of items. Hence the unit cost of the item decreases. i.e., the unit price of an item inversely relates to the demand of that item. So demand rate of an item may be considered as a decision variable.

Zadeh [6] first gave the concept of fuzzy set theory to solve decision making problem. Tanaka [5] introduced objectives as fuzzy goals over the α-cut of a fuzzy constraints set. Zimmerman [1] gave the concept to solve multi objective linear programming problem. Now the fuzzy set theory has made an entry into the inventory control systems.

Park [3] examined the EOQ formula in the fuzzy set theoretic perspective associating the fuzziness with the cost data. Mandal [2] has formulated the multi objective fuzzy inventory model with three constraints and solved by geometric programming method. Panda [7] has formulated multi item stochastic inventory model under imprecise goal and chance constraints. In all of the above articles, the warehouse space available in the selling store is taken in terms of area. If the warehouse space is taken in terms of volume then less percentage of volume of the warehouse space will be consumed. Consequently, the maximum of the volume of the warehouse space can be utilized effectively.

Prasath [8] has optimized the total expenditure of the organization by using multi objective fuzzy inventory model and warehouse location problem, the available warehouse space in the selling store has been taken in terms of area.

In this paper, a multi item multi objective inventory model with constraints such as warehouse space, investment amount and percentage of utilization of volume of the warehouse space has been formulated where the unit cost parameter is imposed in fuzzy environment. The unit cost and lot size are the decision variables. The volumes of the unit items are taken for calculations.

II. ASSUMPTIONS AND NOTATIONS

A multi-item, multi-objective inventory model is developed under the following notations and assumptions.

- **Notations**

n = number of items

I = Total investment cost for replenishment

V = Volume of the warehouse space

L = Inside length of the warehouse

B = Inside breadth of the warehouse

M = Maximum height of the shelf

For i^{th} item ($i = 1, 2 \ldots n$)

S_i = Set-up cost per cycle

$D_i = D_i(p_i)$ Demand rate [function of cost price]

H_i = Inventory holding cost per unit item

Q_i = lot size (decision variable)

p_i = Price per unit item (fuzzy decision variable)

v_i = Volume of the unit item i

l_i = Length of the unit item i

b_i = Breadth of the unit item i

h_i = Height of the unit item i

V_W = Percentage of utilization of volume of the warehouse

- **Assumptions**
  - Replenishment is instantaneous
  - Shortage is not allowed
  - Lead time is zero
  - Demand is related to the unit price as

$$D_i = \frac{1}{\beta_i}\ln\left(\frac{\alpha_i}{p_i}\right)$$

Where $\alpha_i > 0$ and $\beta_i > 0$ are real constants selected to provide the best fit of the estimated price function.

Volume of the unit item is defined by $v_i = l_i \times b_i \times h_i$

To calculate the volume of the warehouse space, multiply the lengths of the dimensions of the inside of the warehouse, that is multiply inside length, inside breadth and maximum shelf height. i.e. Volume of the warehouse space is defined by

$$V = L \times B \times M$$

III. FORMULATION OF INVENTORY MODEL

The total cost = Purchasing cost + Set up cost + Holding cost

$$Min\ Z = p_i D_i + \frac{S_i D_i}{Q_i} + \frac{H_i Q_i}{2}$$

$$= \frac{p_i}{\beta_i}\ln\left(\frac{\alpha_i}{p_i}\right) + \frac{S_i}{Q_i\beta_i}\ln\left(\frac{\alpha_i}{p_i}\right) + \frac{H_i Q_i}{2} \text{ for } i = 1, 2, 3 \ldots n$$

Therefore we get,

$$\text{Min } Z = \sum_{i=1}^{n} \frac{p_i}{\beta_i}\ln\left(\frac{\alpha_i}{p_i}\right) + \frac{S_i}{Q_i\beta_i}\ln\left(\frac{\alpha_i}{p_i}\right) + \frac{H_i Q_i}{2}$$

There are some restrictions on available resources in inventory problems that cannot be ignored to derive the optimal total cost.

- There is a limitation on the available warehouse space in the store,

$$\sum_{i=1}^{n} v_i Q_i \leq V$$

- Investment amount on total production cost cannot be infinite; it may have an upper limit on the maximum investment.

$$\text{i.e.} \sum_{i=1}^{n} p_i Q_i \leq I; \quad \text{where } p_i, Q_i > 0, \text{for } i = 1, 2, 3 \ldots n$$

- Percentage utilization of the volume of the warehouse,

$$\text{i.e.}\ \frac{V \times V_W}{(\sum_{i=1}^{n} Q_i) \times 100} = 1, 0 \le V_W \le 100$$

IV. INVENTORY MODEL UNDER FUZZY ENVIRONMENT

When p_i 's are fuzzy decision variables, the above crisp model under fuzzy environment reduces to

$$\text{Min } Z = \sum_{i=1}^{n} \left[\frac{\tilde{p_i}}{\beta_i} \ln\left(\frac{\alpha_i}{\tilde{p_i}}\right) + \frac{S_i}{Q_i \beta_i} \ln\left(\frac{\alpha_i}{\tilde{p_i}}\right) + \frac{H_i Q_i}{2} \right]$$

Subject to the constraints

$$\sum_{i=1}^{n} v_i Q_i \le V$$

$$\sum_{i=1}^{n} \tilde{p_i} Q_i \le I; \quad \text{where } \tilde{p_i}, Q_i > 0$$

[Here cap '~' denotes the fuzzification of the parameters.]

V. MEMBERSHIP FUNCTION

The membership function for the triangular fuzzy number $\tilde{p_i} = (k_{u_i}, k_{m_i}, k_{o_i}), i = 1, 2, 3 \ldots n$ is defined as follows

$$\mu_{p_i}(X) = \begin{cases} \dfrac{p_i - k_{u_i}}{k_{m_i} - k_{u_i}}, & k_{u_i} \le p_i \le k_{m_i} \\ \dfrac{k_{o_i} - p_i}{k_{o_i} - k_{m_i}}, & k_{m_i} \le p_i \le k_{o_i} \\ 0, & \text{otherwise} \end{cases}$$

VI. NUMERICAL EXAMPLE

The model is illustrated for one item and also the common parametric values assumed for the given model are

$n = 1, \beta_1 = 0.1, S_1 = \$100, H_1 = \$1, \tilde{p_1} = \$(10,15,20),$

$I = \$1400, l_1 = 2\text{ m}, b_1 = 3\text{ m}, h_1 = 4\text{ m},$

$L = 10\text{ m}, B = 12\text{ m}, M = 30\text{ m}.$

Therefore $v_1 = l_1 b_1 h_1 = 24\text{m}^3$ and $V = LBM = 3600\text{m}^3$

The proposed model is solved by using LINGO software and the optimal results are presented in the following table:

Table 1

α_1	p_1	μ_{p_1} Value	Q_1	V_W	Z
85	10.051	0.0102	65.34	43.56	279.93
86	11.351	0.2703	63.64	42.43	293.51
87	12.729	0.5459	62.00	41.33	306.66
88	13.268	0.6536	61.51	41.01	312.54
89	14.106	0.8213	60.7	40.46	320.54
90	14.832	0.9665	60.05	40.03	327.48
91	16.036	0.7927	58.92	39.28	337.32
92	17.371	0.5258	57.74	38.49	347.31
93	18.870	0.2259	54.48	37.65	357.50
94	19.753	0.0494	55.86	37.24	364.00

In the Table 1, the values of p_1, μ_{p_1}, Q_1, V_W and Z are finding out by applying different values for α_1.

VII. CONCLUSIONS

In this paper we have proposed a concept of the optimal solution of the inventory problem with fuzzy cost price per unit item. As there is nothing like fully rigid in the world fuzzy set theoretic approach of solving an inventory control problem is realistic. Here the fuzzy inventory model is taken with three constraints, volumes of the unit items are taken in the warehouse space constraint. By solving the above fuzzy inventory model, the optimal result will be calculated. The result reveals the minimum expected annual total cost of the inventory model and also the optimal percentage of utilization of the volume of the warehouse. In the result, the percentage of utilization of the volume of the warehouse space is less; it can be increased by changing the values like volume of the warehouse space, investment cost, etc. The above discussed model can be developed with many limitations, such as the number of orders, shortage level, etc.

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Mr. Prakash D Patel was born on 19 August 1979. He has done his Master of Science in 2001 and Master of Philosophy in 2004 in Pure Mathematics from Sardar Patel University, Vallabh Vidyanagar, Gujarat, India.

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